Application of Mean-Shift Algorithm for License Plate Localization

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***Abstract*--This paper discusses about localization of license plate from vehicle images using different methods. And main focus is on Mean Shift Algorithm which is a non parametric feature space analysis technique. It defines a window around each data points and shifts the center of the window to the mean of the data point though a Mean-Shift Vector till it converges and window shifts to the denser region. The other methods used are Crop Object, Morphological operations, Localize the object by thresholding and area of object. We also discuss how Mean-Shift algorithm is accurate enough and robust to be used in the same area. This includes the basic definition of the algorithm and mathematical equations.**

***Index Terms*—Automatic license plate recognition, kernel density, localization, mean shift vector, threshold.**

I. INTRODUCTION

IMAGE processing is nowadays used in many real time applications and will find a more use in nearby future. The applications are generally based on extracting useful information from images and processing images for human interpretation and its further modifications that may be either enhancing the information content in the image or compressing it.

In the development of an *automatic license plate recognition system*, localization of license plate is the first step followed by image segmentation, character recognition and learning. In India license plate background is normally light (either yellow or white) compared to the characters (black). On this basis unwanted objects can be filtered out from the image. To do it we can use few different methods like edge detection, row by row pixel scanning, cropping object, object filtering using threshold, morphological operation etc. But the results obtained were not up to the mark for all images. While mean shift algorithm gives better results as it is a density based object tracking method.

II. RELATED WORK

Excellent work has been done in localization of license plate in order to implement An Efficient Intelligent Traffic Systems. Considering Indian Traffic this can be really helpful system. The most used algorithm for localization is morphological operations and edge detection. Generally localization algorithms are based on edge, color intensity, or threshold etc. The Mean shift procedure was originally invented by Fukunaga and Hostetler in 1975. It is a accurate algorithm which very useful in vision based applications. In [1], mean shift algorithm is also used for object tracking. Moving object tracking can also be achieved by using Bhattacharyya coefficient within mean shift algorithm, used in [6]. Given a grayscale image as input, edge detection and morphological operations can be used to localize license plate, used in [3]. In [2] a fast algorithm is described for license plate detection using vertical edge map and cascade classifiers.

III. CROP OBJECT

This is the simplest method to extract an object from image. But it is manual so it cannot be used for real time system. Given an input image, we can crop an object manually with mouse, and we can extract it using the data points. As this method involves user to manually crop the object, it is unsuitable for any automatic system.

IV. MORPHOLOGICAL OPERATIONS

Morphology is based on mathematical set theory and it is a powerful tool for handling numerous image processing problems. It can be applied for operations like filtering, segmentation, measurement, extraction etc.

Figure - 1 is the input RGB image. Various morphological Operations can be combined together to produce a desired result. And for that operations such as dilation, erosion, closing, opening, and other based on regions are available in MATLAB. The images shown below are results of the Following process carried out.

Original image → binary image

Erosion

Dilation

Thesholding (0.45)

In mathematical terms for sets A and B, erosion is $AB + \overline{A\overline{B}}$ and dilation is $A\bar{B} + \bar{A}B$. By using the properties of image regions dilation and erosion are used. Figure – 2 is the eroded image and Figure – 3 is dilated image. Where Figure – 4 is the dilated image on which threshold value of 0.45 is applied to differentiate particular object from the background. A structuring element can be defined in order to remove unwanted region.

Fig. 1. Origional image [7]

Fig. 2 Eroded image

Fig. 3 Dilated image

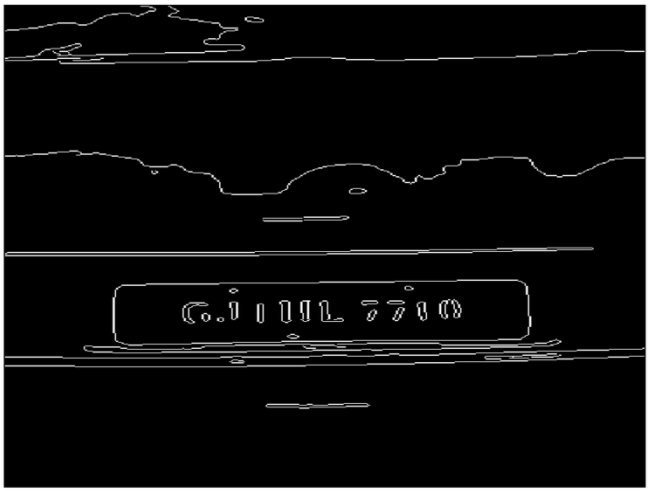

Fig. 4 Threshold after dilation

Some of the morphological operations are limited to binary images. So it may be a difficult procedure to extract license plate as color information of the image gets lost.

V. LOCALIZE THE OBJECT BY THRESHOLDING AND AREA OF THE OBJECT

This can be a useful method. In it we combine filters based on number of pixels contained in an area. The idea is that in an image there can be various objects present other than license plate. So we can employ filters which reduce these objects to an image with license plate only.

Here firstly original image is converted into grayscale. Then two filters are employed to get license plate. Figure – 5 is the histogram of the image and in it a red line shows the threshold value defined which filters the objects. Left to red line are objects with fewer thresholds and to the right are with higher threshold. This is the first filter. Then one more filter is employed based on number of pixels contained in an area or object. In this image, compared to license plate other objects contain less number of pixels. A boundary can be created on the object obtained after this which can be seen in figure 6. And it can be extracted.

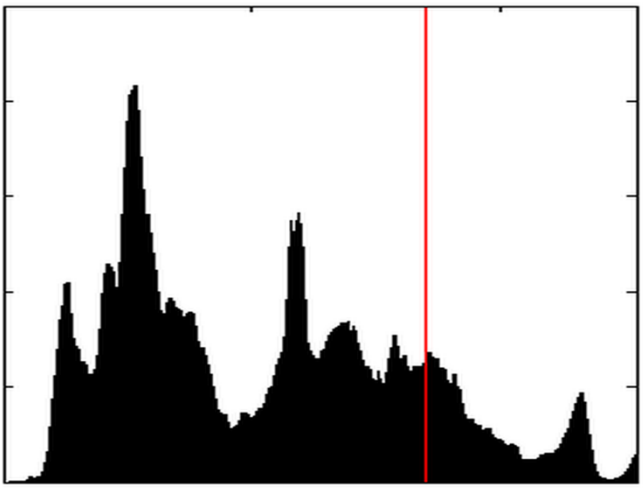

Fig. 5 Histogram (Red line-threshold 170)

Fig. 6 Result of localization by thesholding

Fig. 7 Extracted license plate

The problem we faced with this method is that if the car is white then the result will contain some unwanted objects. So it fails to detect only license plate in such cases.

VI. MEAN-SHIFT ALGORITHM

Mean-Shift algorithm is useful for the modes of density. It is a non-parametric statistical method for locating maxima of a density function given discrete data samples from that function. It shifts the center of the window to the mean of the window. Figure - 8 shows the window around all data point and in Figure – 9 the blue data points were traversed by the window towards the mode.

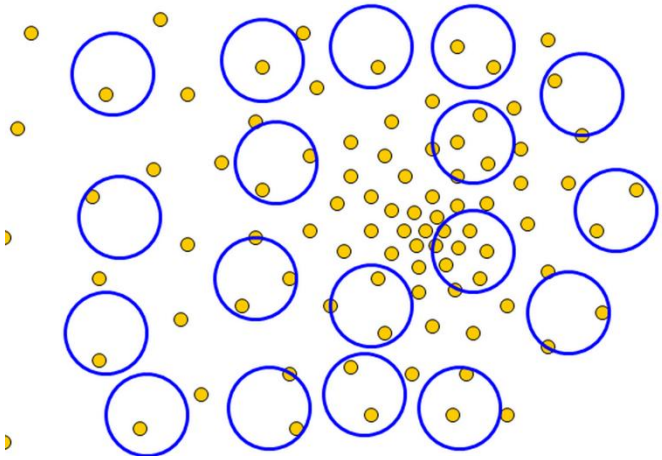

Fig. 8 Window around each data point [11]

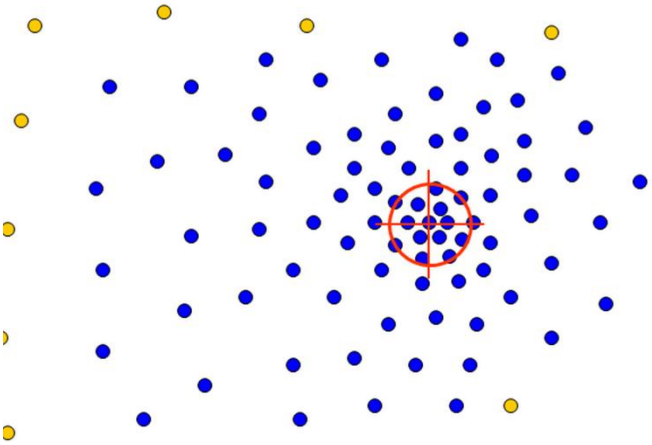

Fig. 9 All windows towards the mode [11]

Steps for implementing this algorithm:-

1. Fix windows around each data point.
2. Find the center and the mean of those windows
3. Find the kernel density estimator given by the following function

$$f(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \quad (1)$$

Where K(x) is a kernel function and the necessary conditions for the kernel are $\int K(x)dt = 1$ and $K(x) \geq 0$. And h is the bandwidth; it has a value between 0 to 0.5. And d is the dimensions of the image. There are various types of kernel used, which are shown in below table. Generally Gaussian kernel is preferred most in image processing.

TABLE I
TYPES OF KERNEL FUNCTIONS [4]

Kernel	K(x)
Uniform	$\frac{1}{2}1, (\lvert x\rvert \leq 1)$
Triangle	$(1 - \lvert x\rvert)1, (\lvert x\rvert \leq 1)$
Epanechnikov	$\frac{3}{4}(1 - x^2), (\lvert x\rvert \leq 1)$
Quartic	$\frac{15}{16}(1 - x^2)^2 1, (\lvert x\rvert \leq 1)$
Triweight	$\frac{35}{32}(1 - x^2)^3 1, (\lvert x\rvert \leq 1)$
Gaussian	$\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2} 1, (\lvert x\rvert \leq 1)$
Cosinus	$\frac{\pi}{4}\cos(\frac{\pi}{2}x)1, (\lvert x\rvert \leq 1)$

4. Calculate the $\vec{x}$
   Equation for the gradient ascent is

$$x_1 = x_0 + \eta f'(x) \quad (2)$$

Applying it to kernel density estimator

$$\hat{f}(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \quad (3)$$

$$\nabla\hat{f}(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K'\left(\frac{x - x_i}{h}\right) \quad (4)$$

From this (3) and (4) equation we will get

$$\vec{x} = \frac{\sum_{i=1}^{n} k'(\frac{x - x_i}{h})x_i}{\sum_{i=1}^{n} k'(\frac{x - x_i}{h})} \quad (5)$$

5. Calculate the mean-shift m(x).

$$m(x) = \frac{\sum_{i=1}^{n} k'(\frac{x - x_i}{h})x_i}{\sum_{i=1}^{n} k'(\frac{x - x_i}{h})} - x \quad (6)$$

Assuming $g(x) = -k'(x)$.

6. Compute the mean-shift vector $m(x_i^t)$.
7. Move the density estimator window by $m(x_i^t)$.
8. Repeat till convergence.

Figure – 10 shows the mean shift vector. This window will shifts by the vector till convergence.

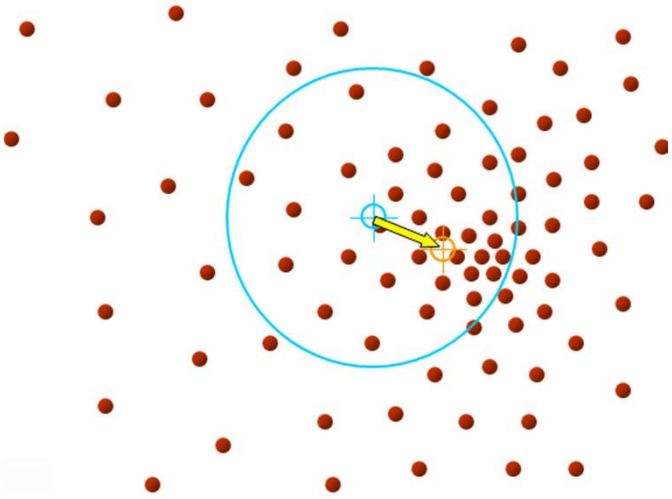

Fig. 10 Mean-shift vector [11]

We are currently working on mean shift algorithm and its implementation. It clusters together the pixels which have the same or nearer intensity value. Using a generalized aspect ratio of license plate it can be extracted. And the desired result is similar to that shown in below figure.

Fig. 11 Mean shift segmentation [12]

VII. CONCLUSION

In Morphological operations as they mainly operate on binary images so time parameter is not that important. As the next method localization by thesholding contains more steps and filters to remove non-plate objects, it takes a bit longer time compared to the above method. As explained above mathematical computation in mean shift algorithm is little complex. Implementing the same contains so many numbers of loops, so it takes much longer time to produce the required result. And few critical conditions must be considered to break the loop.

VIII. REFERENCES

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